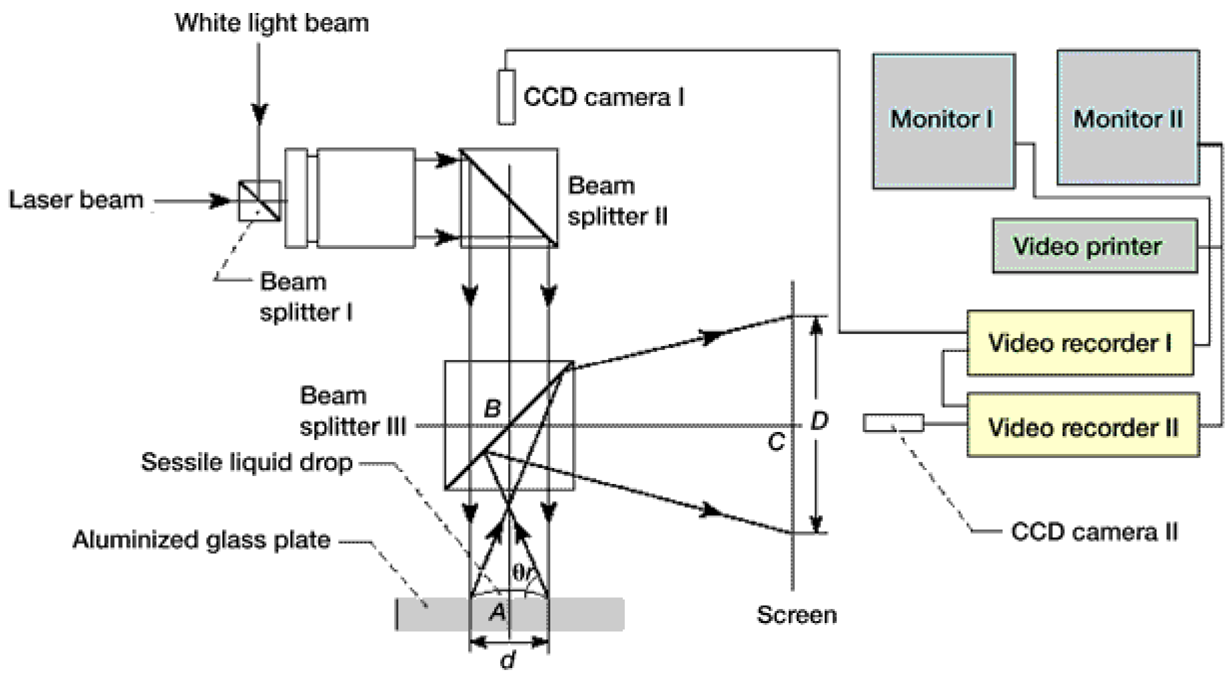
Contact Angle of Drops Measured on Nontransparent Surfaces and Capillary Flow Visualized

The spreading of a liquid on a solid surface is important for various practical processes, and contact-angle measurements provide an elegant method to characterize the interfacial properties of the liquid with the solid substrates. The complex physical processes occurring when a liquid contacts a solid play an important role in determining the performance of chemical processes and materials. Applications for these processes are in printing, coating, gluing, textile dyeing, and adhesives and in the pharmaceutical industry, biomedical research, adhesives, flat panel display manufacturing, surfactant chemistry, and thermal engineering.

A very simple, accurate, and unique hybrid optical technique for simultaneously measuring the dynamic contact angle and the spreading rate of a liquid drop (with flow visualization in the drop) on a nontransparent metal substrate has been demonstrated at the NASA Glenn Research Center to obtain comprehensive information about contact angles along the periphery of the drop. This process is a new method for measuring contact angles of drops and extends our ability to understand the spreading process of drops by providing information on capillary convection within drops and the effects of evaporation on contact angles over the entire circumference of the drop. These effects are critical to understanding the spreading process but are beyond the range of standard testing procedures. Contact angles anywhere on the circumference can be determined simultaneously. The direct benefits of this technology will be a better understanding of how liquids interact with surfaces, leading to improved and cheaper products as well as improved process control.

Instant reflection-refracted shadowgraph of Freon-113.

The apparatus (see the following diagram) consists of an optical system composed of topdown photography and reflection-refracted shadowgraphy. Together, white light and helium-neon laser light are collimated and passed through a droplet placed on a smooth opaque surface (for example, aluminized glass plate). The light beams are reflected by the plate surface and refracted out of the droplet. A beam splitter reorients the reflection-refracted beams horizontally to a vertical screen from which data are recorded. A video recording system synchronously records time-dependent thermocapillary convection and the profile of an experimental droplet on two recorders. Data have shown that evaporation can play a role in inducing thermocapillary convection, depending on both the liquid and the environmental conditions. This patent-pending technology is currently available at the Fluid Physics Branch of Glenn's Microgravity Science Division.



Hybrid optical system consisting of laser reflection-refracted shadowgraphy and direct photography.

Long description of figure 2 Diagram showing white light beam, laser beam, beam splitter I, beam splitter II, beam splitter III, screen, sessile liquid drop, and aluminized glass plate, as well as CCD camera I, monitors I and II, video printer, and video recorders I and II.

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References

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2. Zhang, Nengli; and Chao, David F.: A New Laser Shadowgraphy Method for Measurements of Dynamic Contact Angle and Simultaneous Flow Visualization in a Sessile Drop. Opt. Laser Technol., vol. 34, no. 3, 2002, pp. 243-248.

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